

NON-PUBLIC?: N
ACCESSION #: 9401260303
LICENSEE EVENT REPORT (LER)

FACILITY NAME: Quad Cities Unit One PAGE: 1 OF 05

DOCKET NUMBER: 05000254

TITLE: Engineered Safety Feature Actuations Caused By Main
Turbine Control Logic Relay Failure
EVENT DATE: 12/16/93 LER #: 93-023-00 REPORT DATE: 01/12/94

OTHER FACILITIES INVOLVED: DOCKET NO: 05000

OPERATING MODE: 04 POWER LEVEL: 97

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR
SECTION:
50.73(a)(2)(iv)

LICENSEE CONTACT FOR THIS LER:
NAME: Doug Bucknell, Ext. 2193/Jim Guest, TELEPHONE: (309) 654-2241
Ext. 3161

COMPONENT FAILURE DESCRIPTION:
CAUSE: X SYSTEM: TA COMPONENT: RLY MANUFACTURER: C345
REPORTABLE NPRDS: Y

SUPPLEMENTAL REPORT EXPECTED: NO

ABSTRACT:

At 2355 hours on December 16, 1993, the Unit-1 main turbine TA! tripped from 97 percent reactor core thermal power. The turbine stop valve closure initiated a reactor scram. Spurious main steam line low pressure signals generated a group one primary containment isolation (PCI) JM!. The turbine trip was caused by a main condenser SG! low vacuum signal, but vacuum was found to be normal. The main steam isolation valves were reopened and a reactor cooldown was started. A relay contact for condenser low vacuum turbine trip was found to have failed in the closed position.

The root cause of this event was a relay failure due to manufacturing specification. A contributing cause of this event was design analysis.

The relay was replaced like for like and tested satisfactorily. Other

trip relays that provide turbine trip signals, but are not routinely tested through periodic surveillance were tested prior to start up. The station is investigating options for improving the reliability and possibly adding redundancy to the turbine trip logic.

LER254\93\023.WPF

END OF ABSTRACT

TEXT PAGE 2 OF 5

PLANT AND SYSTEM IDENTIFICATION:

General Electric - Boiling Water Reactor - 2511 MWt rated core thermal power.

EVENT IDENTIFICATION: Engineered Safety Feature Actuation Caused By Main Turbine Control Logic Relay Failure.

A. CONDITIONS PRIOR TO EVENT:

Unit: One Event Date: December 16, 1993 Event Time: 2335
Reactor Mode: 04 Mode Name: Run Power Level: 97

This report was initiated by Licensee Report 254\93-023.

RUN (4) - In this position the reactor system pressure is at or above 825 psig, and the reactor protection system is energized, with APRM protection and RBM interlocks in service (excluding the 15% high flux scram).

B. DESCRIPTION OF EVENT:

On December 16, 1993, Unit-1 was maintaining load at 97 percent core thermal power. At 2355 hours the main turbine TA! tripped. The turbine stop valve closure produced a reactor scram. Spurious main steam line low pressure signals generated a group one primary containment isolation (PCI) JM! that resulted in a main steam isolation valve (MSIV) SB! closure. A low reactor vessel water level trip occurred, due to the collapse of voids, producing group two and group three primary containment isolations JM!. The reactor building ventilation VA! and control room ventilation VI! isolated, and the standby gas treatment system BH! initiated as designed. Control room alarms indicated that the turbine trip was caused by main condenser SG! low vacuum. Vacuum was found to be normal and the MSIVs were reopened. The scram recovery was

performed in accordance with QCGP 2-3, "Reactor Scram". QCGP 2-1 "Normal Unit Shutdown" was performed to complete the shutdown to cold conditions. Other than the group one PCI, there were no unanticipated Engineered Safety Feature (ESF) actuations.

The electro-hydraulic control (EHC) TG! logic continued to sense a low condenser vacuum signal. A team of station personnel was assembled to begin an investigation. A plan was developed that sequenced the troubleshooting effort in order to minimize disturbing the low vacuum trip logic. The EHC trip circuitry utilizes relays with "energize to close" contacts that cause the turbine trip. The relay for condenser low vacuum was found in the de-energized state, however the contacts had failed in the closed position.

LER254\93\023.WPF

TEXT PAGE 3 OF 5

C. APPARENT CAUSE OF EVENT:

The reactor scram was the result of a turbine stop valve closure after a main turbine trip. The turbine trip was caused by a relay failure in the EHC logic circuitry. Relay K2-D18 provides a turbine trip and an alarm in the control room for low main condenser vacuum. Two pressure switches are provided in each low pressure turbine hood section. Both low vacuum pressure switches in any one of the three hoods will cause the K2-D18 relay to energize and the contact to close. The relay contact was found to be closed without any pressure switch actuation and with the relay coil being de-energized. Relay K2-D18 is a mercury wetted relay, model number HGSM5001 manufactured by C.P. Clare and Company. Mercury wetted relays of this type are used extensively in the station's EHC logic circuitry. They are mounted directly on circuit boards. Additional testing of the K2-D18 relay was performed following removal from the circuit board. The relay failure was found to be intermittent and sensitive to vibration.

Institute of Nuclear Power Operations (INPO) Significant Event Report (SER) 27-89, "Common Mode Failures of Mercury-Wetted Relays" addressed failures of relays manufactured by Potter-Brumfield and C.P. Clare. This paragraph is a brief overview of the SER. The failure mode is that over time nickel from the relay contacts dissolves into the mercury. The solution possibly may form a bridge across the contact surfaces. The failures first appeared in reactors of Canadian design that use the mercury wetted relays in safety related applications. Mercury wetted relays are highly

reliable when periodically exercised. The relays that failed were tested on a low frequency (yearly). The long intervals between operation lead to both infrequent exercising of the relay and poor detection of failures. Currently no recommendations exist for the maximum time interval required between tests to prevent occurrence. No reference was made of failures due to aging.

INPO Significant Operating Experience Report (SOER) 84-06 "Reactor Trips Caused By Turbine Control And Protection System Failures" recommended the following. "Turbine control and protection system designs should be reviewed and circuitry should be modified where practical to minimize trips due to single-component failures." All Quad Cities turbine trip circuitry is vulnerable to single relay failures. In 1985, a review was done of all turbine trips at Quad Cities since 1978. No chronic cause of turbine trips was identified therefore no action was deemed necessary. In 1992, the station again reviewed SOER 84-06. No further actions were determined to be necessary at that time. The station's response to SOER 84-06 was then considered closed.

The ROOT CAUSE of this event was a relay failure due to MANUFACTURING SPECIFICATION. Based on industry experience with this relay, nickel from the relay contacts interacts with the mercury creating a failure mechanism leading to the spurious closure of the contact.

LER254\93\023.WPF

TEXT PAGE 4 OF 5

A CONTRIBUTING CAUSE of this event was DESIGN ANALYSIS. The system has a functional design deficiency in that it will not withstand the failure of a single relay without causing a turbine trip. General Electric designed the EHC system more than two decades ago. More recent turbine trip logic designs have greater redundancy.

D. SAFETY ANALYSIS OF EVENT:

The safety significance was minimal. The failure of the K2-D18 relay was in the safe direction and did cause a turbine trip. The reactor scram occurred as expected upon turbine stop valve closure. The closure trip setpoint is set at the Technical Specification limit of 10% or less from the full-open position. The purpose of the turbine stop valve closure scram trip is to protect the reactor whenever it is sensed that its link to the heat sink is in the process of being removed. The trip anticipates the pressure,

neutron flux, and the heat flux increase that could result from rapid closure of the turbine stop valves. With the Technical Specification scram trip setting, the resultant increase in fuel cladding surface heat flux is limited such that minimum critical power ratio (MCPR) remains above the fuel cladding integrity safety limit MCPR even during the worst-case transient that assumes the turbine bypass is closed. The low reactor level trip and resulting actuations occurred as designed and are expected during a scram from this power level. Therefore this event is bounded by an existing analysis and no safety limits were exceeded.

The spurious group one isolation was caused by a known problem. The station has previously determined that pressure fluctuations in the main steam lines (MSL) occur as a result of the rapid closure of the main turbine stop valves. A modification has been designed to prevent spurious group one isolations of this type. The installation requires an outage and presently is scheduled for Q1R13 and Q2R13. The recovery from the group one did not have a significant impact on the operators' ability to safely control the plant.

E. CORRECTIVE ACTIONS:

Relay K2-D18 was replaced like for like and tested satisfactorily. The remaining relays on the circuit board were tested and one additional relay was replaced.

A search was made of all station uses of mercury wetted relays. The only uses found for this type of relay were non-safety related applications in the EHC system. EHC system relays that provide turbine trip signals but can not be routinely tested were identified. These relays were tested satisfactorily three times prior to Unit-1 start up. The Unit-2 EHC system relays were tested during the current maintenance outage under nuclear work request Q13052. No failures of mercury wetted relays were found.

The station is investigating options for improving reliability and possibly adding redundancy to the turbine trip logic. Modifications will be made if deemed necessary. The station's response to INPO SOER 84-06 will be reviewed after the study is complete (NTS# 2541809302301).

LER254\93\023.WPF

TEXT PAGE 5 OF 5

F. PREVIOUS EVENTS:

Quad Cities has not experienced any other turbine trips due to a failure of a mercury wetted relay. The following is a list of reactor scrams from turbine trips caused by component failures since 1986.

LER 254/86-30 Reactor Scram Due To Pressure Transient

LER 254/88-16 Reactor Scram Due To Stop Valve Closure From A Turbine Trip- Cause Undetermined

LER 254/89-03 Reactor Scram Due To EHC Circuit Problems

LER 254/89-10 Reactor Scram From An Induced Voltage Due To A Loose Wire On The Condenser Low Vacuum Pressure Switch Indicating Lamp

LER 265/87-20 Reactor Scram Due To Failure Of The Turbine Master Trip Solenoid Valve

LER 265/88-01 Reactor Scram, Group 2 and Group 3 Isolations, SBTG Auto Started From Turbine-Generator Load Reject Due To Unknown Causes

LER 265/89-01 Turbine Trip and Reactor Scram While Testing Master Trip Solenoid Valve

LER 265/90-10 Reactor Scram Due To Turbine Trip From 2C Moisture Separator High Level Due To Blocked Drain Line On The 2C Level Switch

G. COMPONENT FAILURE DATA:

Relay K2-D18, was manufactured by C.P. Clare & Co. Type is a mercury wetted relay model number HGSM5001.

LER254\93\023.WPF

ATTACHMENT TO 9401260303 PAGE 1 OF 1

Commonwealth Edison
Quad Cities Nuclear Power Station
22710 206 Avenue North
Cordova, Illinois 61242
Telephone 309/6
4-2241

GGC-94-007

January 12, 1994

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555

Reference: Quad Cities Nuclear Power Station
Docket Number 50-254, DPR-29, Unit One

Enclosed is Licensee Event Report (LER) 93-023, Revision 00, for Quad Cities Nuclear Power Plant Station.

This report is submitted in accordance with the requirements of the Code of Federal Regulations, Title 10, Part 50.73(a)(2)(iv). The licensee shall report any event or condition that resulted in manual or automatic actuation of any Engineered Safety Feature.

Respectfully,

COMMONWEALTH EDISON COMPANY
QUAD CITIES NUCLEAR POWER STATION

G. G. Campbell
Station Manager

GGC/TB/plm

Enclosure

cc: J. Schrage
T. Taylor
INPO Records Center
NRC Region III

STMGR\00794.GGC

*** END OF DOCUMENT ***
